Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

Resources Policy 75 (2022) 102531

Contents lists available at ScienceDirect

Resources Policy

journal homepage: www.elsevier.com/locate/resourpol

Oil prices volatility and economic performance during COVID-19 and financial crises of 2007–2008

Yang Yu, SongLin Guo *, XiaoChen Chang

School of Finance, Renmin University of China, China

ARTICLE INFO

Keywords:
Oil price shocks
Economic performance
Global financial crises
COVID-19
Wavelet analysis

ABSTRACT

We examine the time-frequency dynamics of spillovers between oil price shocks and economic performance globally. We use both time and frequency domains simultaneously to find the response of macroeconomic performance to changes in oil prices during the global financial and pandemic crises. Using Wavelet analysis, this seminal study explores the connectedness between oil price shocks and economic activities during COVID-19 and the financial crises of 2008. This study finds that both economic activities and oil prices have shown high power during the period of global financial crises. The recently COVID-19 outbreak indicates significant volatility in economic activities and oil prices during the period of crisis. Moreover, we observe a strong interconnectedness between oil prices and economic activities during global financial crises and COVID-19 crises. We argue that a shock to oil prices in global financial crises and the COVID-19 outbreak has serious repercussions for economic activities. The highest total connectedness between oil prices and economic activities is observed during the COVID-19 outbreak, which advocates that the speed of information transmission amid oil prices and economic activities is greater in the era of the COVID-19 outbreak as compared to other global financial crises. The results of this study have significant implications for policymakers.

1. Introduction

The epidemic coronavirus disease has produced devastating effects globally. The virus brings a series of chain reactions such as a surge in unemployment, a drop in oil prices, and a decline in the stock markets (Su et al., 2020a, 2021a). The novel coronavirus has had an unprecedented global impact. This lethal virus has had a significant impact on a large number of countries. The World Health Organization (WHO) reported 226.84 million confirmed coronavirus cases and 4.67 million people losing their lives as of September 20, 2021. Governments are attempting to combat the virus by introducing extensive diagnostic testing and social distancing recommendations. The goal is to place human health at the top of the priority list. The COVID-19 pandemic has badly affected the economies. Among others, the oil market is the worst affected market. A considerable level of uncertainty in the oil market added further challenges to policymakers and investors around the globe. Since there is strong nexus between oil and other financial markets, the spillover of oil shocks to other financial markets is considered more persistent during the COVID-19 outbreak. Hence, strong volatility has been observed in other markets. According to (Narayan, 2020), the COVID-19 outbreak has strongly affected the volatility and returns in the oil market.

As the world's largest commodities market, crude oil is a critical component of the global oil price system, and benchmark crudes are a vital component of that system. The price of crude oil has a significant influence on the global economy. On the other hand, oil shocks have a number of key implications for asset allocation and portfolio risk management in international stock markets (Mensi, 2019; Umar et al., 2021b; Wang et al., 2021). The natural resources commodity markets are considered as more efficient in sending a shock to other sectors of the economy. Hence, natural resources commodity markets are more connected with financial, stock, and equity markets. Moreover, it is recognized that the natural resources commodities show extremely volatile behavior in the period of crisis. The financial emergencies and pandemics have encouraged researchers and policymakers to investigate the dynamics of spillovers oil prices and macroeconomic activities (Foglia and Angelini, 2020a; Khan et al., 2020; Sheng et al., 2020a). The spillover of natural resource commodities prices to other markets tends to be more persistent during the crisis period, primarily due to the strong linkages between the farmer and the latter. On the same analogy, it is

* Corresponding author. 59 Zhongguancun Street, Haidian District, Beijing, China.
E-mail address: gslruc@126.com (S. Guo).

https://doi.org/10.1016/j.resourpol.2021.102531
Received 29 September 2021; Received in revised form 2 December 2021; Accepted 18 December 2021
Available online 22 December 2021
0301-4207/© 2021 Elsevier Ltd. All rights reserved.

argued that oil market spillovers to macroeconomic activities tend to be more persistent. However, the interconnectedness among the natural resource market and macroeconomic activities has not been investigated so far. The visible co-movement in oil prices and macroeconomic activities has attracted the attention of researchers to investigate the interconnectedness between oil prices and macroeconomic performance.

It is widely recognized that oil shocks and their prices are strongly related to economic growth. Many macroeconomic aggregates have been suggested to be unstable as a result of oil price variations in different countries. As a result of this significance, it has been stated that oil price is more unpredictable and unexpected (Bhowmik et al., 2016; Qin et al., 2020; Umar et al., 2021c). A surge in oil prices is attached with increased costs and prices of petroleum products, which in turn decreases productivity and, hence, ends up with low economic growth. Hence, fluctuations in the price of oil have a detrimental impact on economic growth. Since most sectors of the economy, such as transport, power, and industrial sectors, heavily depend on oil consumption, a shock in oil prices and subsequent decrease in its consumption strongly affects major sectors of the economy. Moreover, it is also recognized that uncertainty is bad for the consumer, investors, and economy. The oil market behaves differently in a period of crisis. For instance, in financial emergencies, the oil prices were dropped from $150 to $40. However, the prices started to rise again as soon as the recovery started. Similarly, the oil prices dropped remarkably during the COVID-19 outbreak, which in turn badly affected the revenue of key oil producers (Yarovaya et al., 2021). A high level of volatility is observed in the oil market, and the prices cross the threshold level.

It is recognized that the association between oil price and economic growth is not constant throughout business cycles and crises. Since the spillovers effects of volatility between oil and other macroeconomic activities become more important due to a considerable high level of uncertainty in markets; hence, it is imperative to examine the connectedness between oil prices and GDP in the era of financial emergencies and COVID-19 outbreak. This work adds to the body of knowledge by using time-frequency data of oil prices and economic activities with a wide-ranging coverage in the time dimension (November 2007 till November 2020). Our dataset includes the period from 2007 to 2020, which allows us to explore the effect of the global financial crises (2007–2008) and COVID-19 outbreak (2019–2020). This research explores the interconnectedness of oil prices and macroeconomic activities from a global perspective. Because fluctuations in oil prices significantly impact macroeconomic performance, assessing this impact and projecting how sensitive economic performance during the crises is to these changes is critical. The aim is to find the reaction of economic performance to changes in oil prices during the global financial and pandemic crises. Using Wavelet analysis, this study is the first attempt to examine the interlinked between oil price volatility and economic performance during COVID-19 and the financial crises of 2008. We use time-series variables of GDP and oil prices to analyze the time-frequency dependency of economic activities and oil prices from a global perspective. The purpose is to check the impact of oil shocks in global crises (such as COVID-19 and financial crises of 2008) on economic activities. The results of this study have great implications for policymakers. Using Wavelet analysis, this study finds that both economic activities and oil prices have shown high power during the period of global financial crises. The recently COVID-19 outbreak indicates significant volatility in economic activities and oil prices during the period of crisis. Moreover, we observe a strong interconnectedness between oil prices and economic activities in the era of crises. We argue that oil prices volatility has serious repercussions for economic activities, particularly in global crises. The highest connection between oil prices and economic activities is observed when comparing the COVID-19 outbreak to other global financial crises. This suggests that the flow of information transmission between oil prices and economic activities is greater during the COVID-19 outbreak than during other global financial crises.

The remainder of the paper is organized as follows: the next section provides a review of relevant literature covering all of the variables used in the study; Section-3 presents details of the methodology; Section-4 presents empirical findings and their discussion. The concluding remarks are given in the last section.

2. Literature review

The literature on the impact of energy commodities on output is well documented (Ahmad and Du, 2017; Aydin and Esen, 2016; Kilian, 2008; Li et al., 2020; Mustapha and Fagge, 2015; Nasreen et al., 2020; Tang et al., 2016; Yan et al., 2021; Zhang et al., 2021). Energy is the engine of economic growth (Tang et al., 2016; Umar et al., 2020, 2021a), and Oil, which contributes one-third of global energy consumption, is considered the main energy source. In recent years, energy consumption, predominant by oil, has been increasing at an extraordinary speed. However, due to the volatile behavior of oil during the period of crises and the strong connectedness of the oil with other markets, the oil sector has significantly affected the macroeconomic activities in the coronavirus pandemic. The connection between the oil market and other markets has been widely examined in the literature (Awartani et al., 2016; Bibi et al., 2021; Cong et al., 2008; Foglia and Angelini, 2020a; Gu et al., 2020; Ji et al., 2021; Maghyereh et al., 2016; Reboredo, 2015; Sadorsky, 2012; Su et al., 2021b, 2020b). Different researchers have examined the connectedness of oil prices with different markets, such as financial markets (Awartani et al., 2016), clean energy markets (Foglia and Angelini, 2020a; Reboredo, 2015), the stock market (Nasreen et al., 2020), equity markets (Awartani et al., 2016). The nexus between oil prices and macroeconomic performance has attained massive importance from researchers and policymakers during the last several years (Sadorsky, 2012). Additionally, the volatility of oil prices receives a great deal of attention in the academic literature. The record high volatility in oil prices and correspondingly spillovers to other markers has increased the attention of researchers to work on the dynamics of these spillovers (Okonjo-Iweala, 2009). stated that oil prices are more volatile than any other products, resulting in unfavorable consequences on the real product side of the equation.

The global recession of the 1970s laid a solid base for future research on the connectedness between oil price changes and macroeconomic performance. The seminal work of (Rasche and Tatom, 1977) has received immense importance. The researchers discovered a substantial link between oil price changes and macroeconomic activity. A number of different research have been conducted to look into the connections between oil price changes and macroeconomic activities. (Darby, 1982; Hamilton, 2009a; Hooker, 1996). These studies explored whether the global recession of the 1970s contributed to oil shocks and correspondingly economic activities. The existing literature employed two distinct methodologies to cover the dynamics of oil price shocks and economic activities, i.e., findings of transmission mechanism channels and empirical investigation. At the start of the 21st century, the world had seen another episode of oil price shocks. Correspondingly, several studies were carried out to examine the movements of oil prices with macroeconomic activities (Du et al., 2010). The world has observed another peak in oil prices during the global financial crises of 2008, which further attracted researchers to find out the connectedness between oil price shocks and economic performance (Essaadi and Boutahar, 2008; Hamilton, 2009a). The recent COVID-19 outbreak has strongly affected the volatility and returns in the oil market and hence, attained enormous attention from researchers to explore the dynamics of spillovers between oil price shocks and other markets (Foglia and Angelini, 2020a; Sharif et al., 2020; Sheng et al., 2020a). On the incidence of the COVID-19 outbreak, considerable research has been carried out in the past couple of years (Ashraf, 2020; Bouri et al., 2020; Dutta et al., 2020; Rizwan et al., 2020). (Bouri et al., 2020) investigated the power of uncertainty caused by COVID-19 and other infectious diseases in affecting the volatility of oil returns. Using a newspaper-based index,

the authors found volatility in oil returns during the COVID-19 outbreak. Moreover, the authors found that transmittable diseases have a strong impact on equity and oil markets. Similarly (Dutta et al., 2020), find that the COVID-19 outbreak has significantly affected the global energy markets (Foglia and Angelini, 2020a). examined the volatility interconnectedness of oil with renewable energy firms in the COVID-19 era. Using volatility spillover models, the authors find evidences of strong nexus between markets in the era of the COVID-19 outbreak (Le et al., 2021). identifies the influencing variables to the historic oil price volatility during the COVID-19 epidemic. The results of the ARDL technique show that the major contributors to decline in the oil price in US are emergence of COVID-19 cases, uncertainty, and anticipated volatility.

Additionally, oil futures speculation is an important factor responsible for the collapse of the oil markets. Our expectations were met with the results. The authors suggest that with the eradication of new coronavirus, the work might increase oil demand. According to (Bildirici et al., 2020), oil prices have experienced unprecedented and abrupt swings due to the COVID-19 pandemic. The authors studied the presence of nonlinear behavior in oil prices throughout the pandemic and contemporaneous war. Oil prices demonstrate erratic behavior, according to the experiments. In addition, the current research provides a new hybrid modeling strategy for analyzing oil price volatility (Jeris and Nath, 2020). tried to answer how the UK's policy uncertainties are affected by the spread of the coronavirus. Using the ARDL model, the authors found a strong interconnectedness between COVID-19 cases and UK economic policy uncertainty. The relationship, however, does not hold in the long run (Aloui et al., 2020). used structural VAR model to assess the influence of coronavirus shocks on the energy futures markets, specifically on the S&P GS Indexes for crude oil and natural gas. The authors found that energy commodities respond to COVID-19 shocks in different ways over time, depending on fundamentals, behavioral, and psychological aspects (Abdelsalam, 2020). investigate the extreme impact of oil price volatility on the economic performance in the MENA countries. The unequal and dynamic connection between oil price and economic performance is also investigated. In addition, each MENA oil-exporting and the oil-importing country is subjected to a thorough examination. The author found that changes in oil prices have a positive effect on volatility in oil-exporting countries.

To sum up, the existing literature on the connectedness between the oil market and macroeconomic activities is rich. Several studies have been carried out since (Hamilton, 2009b) pioneering study, but none have come to any conclusive conclusions about the relationship between oil and macroeconomic activities. Given the fact that the first stream of research indicates a negative association between oil shocks and economic output, other empirical studies find positive relationships between oil and macroeconomic activities. The third body of literature describes statistically insignificant relationships. Moreover, a bulk of literature is conducted to examine the movement between oil price shocks and macroeconomic activities during the global recession of the 1970s, oil shock in the 1990s, and global financial crises (2008–09). However, to our knowledge, the volatility spillovers between oil prices and macroeconomic activities in the recent COVID-19 pandemic outbreak have not yet been studied. This seminal study examines the spillovers effects of volatility between oil and other macroeconomic activities in the era of global financial crises and the COVID-19 outbreak. A comparative analysis of the dynamics of spillovers between oil price shocks and macroeconomic activities for different time periods is performed. Additional research should be carried out to consider additional evidence on the relationship between oil and macroeconomic activities. This study contributes to the literature by using time-frequency data of oil prices and economic activities with a wide-ranging coverage in the time dimension (November 2007 till November 2020). Our dataset includes the period from 2007 to 2020, which allows us to explore the effect of the global financial crises (2007–2008) and COVID-19 outbreak (2019–2020). The assessments of the linkage between oil price volatility and macroeconomic activities are specifically more important for short time horizons. Nevertheless, in particular, two periods have gotten much attention: the period of global financial crises and the COVID-19 crises. It is widely acknowledged that severe oil price changes, combined with unfavorable oil supply shocks, were the causes of global macroeconomic volatility and stagflation during the crisis period. Including both time periods of crises enable us to compare the volatility and heterogeneity of key variables in global financial crises with the COVID-19 outbreak. As for the empirical, analytical framework employs the wavelet transform method to examine the relationships between oil prices and economic activity from November 2007 to November 2020.

3. Methodology

3.1. Theoretical basis for the linkage among oil prices and economic growth

The theoretical underpinning regarding the association between oil prices and output is based on the idea that a rise in oil prices will increase manufacturing costs and higher pricing for other goods and services. Therefore, fluctuations in oil prices can significantly impact the prices of other commodities, and as a result, play a significant influence in the association between oil prices and output (Akinsola and Odhiambo, 2020). It has been demonstrated that fluctuations in crude prices are a major contributing factor to financial turmoil and weak economic performance (Akinsola and Odhiambo, 2020). Increased costs and prices of petroleum goods are linked to an increase in oil prices, which reduces productivity and, as a result, results in sluggish economic growth. As a result of the increase in oil prices, there is an increase in the costs and prices of petroleum products, which in turn lowers productivity and results in lower economic growth. As a result, fluctuations in the price of oil have a detrimental impact on economic growth. Hence, oil price shocks have a detrimental impact on economic growth. Because most areas of the economy, such as transportation, power, and manufacturing, rely largely on oil consumption, a spike in oil prices and consequent drop in consumption substantially affect major sectors of the economy. Furthermore, it is well acknowledged that uncertainty is harmful for consumers, investors, and the economy. During the period of crises, the spillover of natural resource commodities prices to other markets tends to be more persistent, primarily due to the strong linkages between the farmer and the latter. On the same analogy, it is argued that oil market spillovers to macroeconomic activities tend to be more persistent. Natural resource commodities markets are thought to be more effective in sending shocks across the economy. As a result, commodity markets for natural resources are more closely linked to financial, stock, and equity markets. The spillover of oil shocks to other financial markets is expected to be more persistent during the COVID-19 epidemic due to the strong link between oil and other financial markets. As a result, we anticipate high volatility in other markets.

3.2. Analytica technique

The wavelet approach is a well-known instrument for researchers in medical and engineering. Nevertheless, in recent years, the strategy has become increasingly popular in other fields such as energy, environment, and business as because it enables for the extraction of highly important information on the time-frequency movement between time series variables that cannot be detected using the other approaches outlined by (Ramsey, 2002), it is particularly useful in the field of statistics. According to (Ramsey, 2002), the wavelet method is preferable to other techniques due to its power to obtain valued information by simultaneously taking the time and frequency dimensions into account. The wavelet power spectrum aids in the acquisition of local information in real-time. A null hypothesis, which states that a stationary process creates the series with a particular background power spectrum, can be used to determine the statistical significance of wavelet power in the

series. It is possible to presume that a peak in the wavelet power spectrum is a real feature with particular percent confidence if the peak is much higher than the background spectrum (Das, 2021).

The wavelet power spectrum (WPS) and wavelet coherence (WC) are the two popular methods of Wavelet analysis. Through the Wavelet coherence method, both the long-term and short-term causal nexus between oil prices and economic activities can be explored from a global perspective. Since this study examines the interlinked between oil prices volatility and economic activities during COVID-19 and the financial crises of 2008; hence, we carried out the wavelet analysis. We use time-series variables of GDP and oil prices to analyze the time-frequency dependency of economic activities and oil prices from a global perspective for the time period November 2007 till November 2020). The purpose is to check the impact of oil shocks in global crises (such as COVID-19 and financial crises of 2008) on economic activities. To serve this purpose, WPS and WC are the most relevant methods. Wavelet () formation is given as:

$$\psi(t) = \pi^{-\frac{1}{4}} e^{-i\omega_0 t} e^{-\frac{1}{2}t^2} \quad \mathrm{p(t),\ t\ =\ 1,2,3} \tag{1}$$

where t indicates the place where the wavelet is operated on a time series. Time and location are represented by k and f. By transforming ψ, we can get ψ k, f parameter. The transformed equation is given as:

$$\psi_{k,f}(t) = \frac{1}{\sqrt{h}} \psi\left(\frac{t-k}{f}\right),\ k,f \in \mathbb{R}, \mathrm{f} \neq 0 \tag{2}$$

After taking the time series data in the form of p(t), the correspondence continuous wavelet function can be found in equation (3):

$$W_p(k,f) = \int_{-\infty}^{\infty} p(t) \frac{1}{\sqrt{f}} \psi\left(\overline{\frac{t-k}{f}}\right) dt \tag{3}$$

By reconstructing the series p(t) with annexing the ψ coefficient, we obtain equation (4) as:

$$p(t) = \frac{1}{C_\psi} \int_0^{\infty} \left[\int_{-\infty}^{\infty} \left| W_p(a,b) \right|^2 da \right] \frac{db}{b^2} \tag{4}$$

To capture the behavior of series, this study uses by using the wavelet power spectrum (WPS) approach. The WPS approach enables us to capture the volatility, vulnerability, heterogeneity, and behavior of variables. The equation of WPS is given as:

$$WPS_p(k,f) = \left| W_p(k,f) \right|^2 \tag{5}$$

Contrary to classic causality tests, the wavelet approach incorporates both time and frequency approaches to analyze the relationship between the time series p(t) and the frequency series q. (t). The time series is transformed using the cross-wavelet transform (CWT).

Wpq (k, f) = Wp (k, f) Wq (k, f), and the squared wavelet coherence of Wpq (k, f) is

$$R^2(k,f) = \frac{\left| C\left(f^{-1} W_{pq}(k,f)\right) \right|^2}{C\left(f^{-1} \left| W_p(k,f) \right|^2\right) C\left(f^{-1} \left| W_q(k,f) \right|^2\right)} \tag{6}$$

where c denotes the smoothing process over time. Through the equation of WPS, we can get more information about the range of the series. $R^2(k, f)$ indicates the connectedness of variables. Warmer color sections in wavelet coherence diagrams imply strong linkages between time series variables, whereas cold or blue areas suggest no connectivity. The direction of substantial causality is represented by arrows enclosed by a black line in wavelet coherence research. The arrows pointing to the left indicate that the time series variables have a negative correlation, while the arrows pointing to the right indicate that the variables are in phase (Kirikkaleli and Güngör, 2021).

4. Results and discussions

Since the article's main purpose is to identify the co-movement of economic activities (measured by GDP) and oil prices within a global perspective, the WPS method is used to identify the rapid changes in oil prices during the period of 2007–2020. The time period is split into three major time periods; 2007–2009, 2010–2018, and 2019–2020. The first period covers the global financial crises, the second period covers COVID and financial crises, and the third period covers the COVID-19 crises. The descriptive statistics of the study's primary variables are presented in the tables below (see Table 1). The mean value of the GDP growth rate is clearly higher between COVID-19 and the period of financial crises. During COVID-19 and financial crises, the GDP growth rate is close to zero. During the financial crisis, however, the average price of oil rose to 81.65624. However, during COVID-19, the average price of oil was 48.33344. The mean value of oil price between COVID-19 and the financial crises period is 74.15813.

4.1. Oil prices and economic activities during the period of global financial crises

The wavelet power spectrum for GDP and oil prices during global financial crises is reported in Figs. 1 and 2. It is evident from these figures that both GDP and OP have shown high power during the period of global financial crises, which indicates significant volatility in economic activities and oil prices during global financial crises. GDP is significantly vulnerable in 2008–08 to 2008–12 (at 4–5 periods of scale). It is evident from Fig. 2 that the oil prices were mostly vulnerable between 2008–03 and 2008–12 at different frequencies. Moreover, there is high heterogeneity in the distribution of GDP and OP in the period of global financial crises. Hence, we conclude that the pattern of the economic activities and oil prices are significantly influenced by the global financial crisis of 2007–08. These results support the earlier findings of (Marina et al., 2018). In the next step, the Wavelet Coherence approach is employed to explore the pattern of co-movements between GDP and oil prices. The wavelet coherence enables us to find out the strength of the correlation between GDP and OP. We observe a high correlation value between GDP and OP with reference to as in Eq. (6). The warm color in the cone represents the high connections among the variables GDP and OP. It is evident that the warm color dominates the cone, and hence, we conclude that there is strong interconnectedness between GDP and OP during the period of global financial crises. Moreover, in the cone, the arrows encircled by the black line represent the dimension of the causality. The decision is made based on the arrow inside the cone. The path of the arrow indicates the nature of causality between GDP and

Table 1
Descriptive statistics.

Financial Crises Period		
	GDP	OP
Mean	0.358973	81.65624
Median	0.566417	76.72500
Maximum	3.652158	145.3100
Minimum	−2.133936	30.28000
Std. Dev.	2.030541	28.44729
COVID-19 Period		
Mean	−0.161270	48.33344
Median	0.609983	53.28000
Maximum	3.550668	66.24000
Minimum	−6.925427	−36.98000
Std. Dev.	3.111271	12.68828
Between COVID-19 and Financial Crises Period		
Mean	3.036264	74.15813
Median	2.898553	77.06000
Maximum	5.005794	113.3900
Minimum	2.452823	26.19000
Std. Dev.	0.574123	22.46931

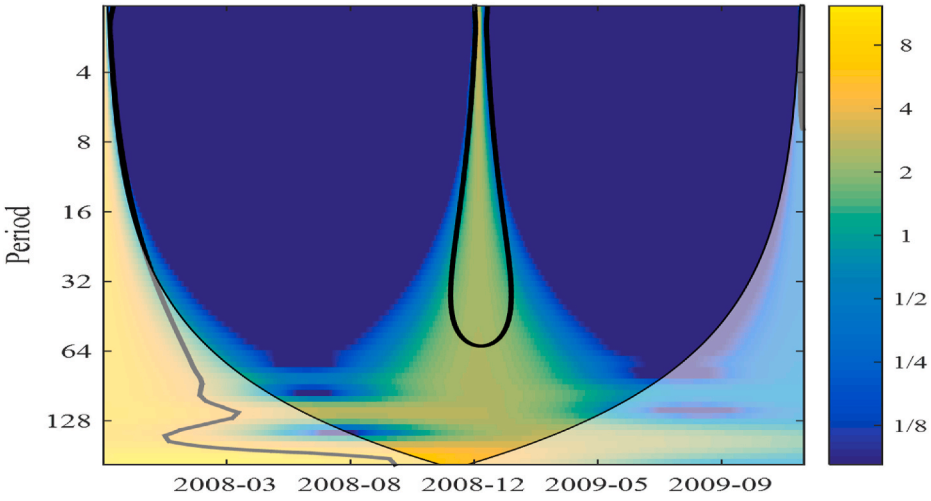

Fig. 1. Wavelet power spectrum for GDP

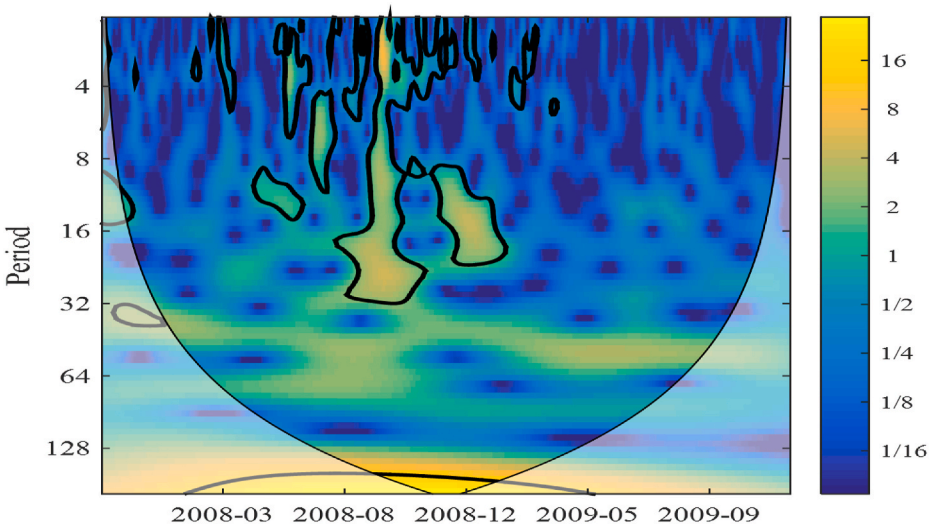

Fig. 2. Wavelet power spectrum for OP.

OP. In Fig. 3, we observe the path of the arrows to the left-down at the relatively higher scales of 16 and 32 periods, which suggests that there is one-way causation between oil prices and economic growth in the long run, supported by the evidence. As a result, we contend that a spike in oil prices during a global financial crisis has major ramifications for economic activity. Moreover, we observe the path of the arrows to the

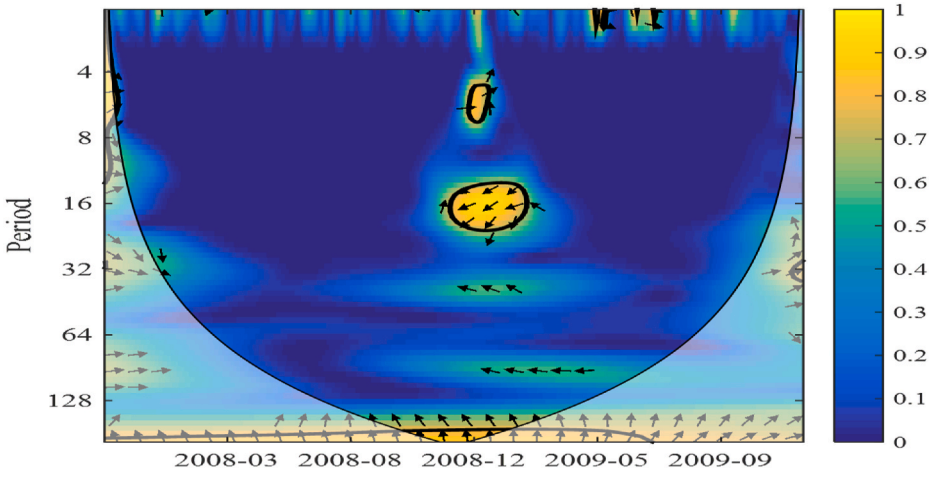

Fig. 3. Wavelet coherence between GDP and OP.

up-right-at-the-low scales of 4 and 8 periods, which implies that there is unilateral causality running from oil prices to economic growth in the short-run. Hence, we infer that any policy to target oil prices significantly influences economic activities.

4.2. Oil prices and economic activities between COVID -19 and financial crisis

This study also investigated the co-movement of economic activities and oil prices during post-financial crises and pre-COVID periods. For this purpose, the wavelet power spectrum (WPS) method is used to identify the changes in oil prices during 2011–2019. The wavelet power spectrum for GDP and oil prices are reported in Figs. 4 and 5, respectively. According to these figures, it is clear that both GDP and OP have shown low power during the period, which indicates less volatility in economic activities and oil prices during the post-global financial crises and pre-pandemic period. It is evident from Fig. 2 that the oil prices were mostly vulnerable between 2011 to 2012 and 2013 to 2015 at low frequencies. Moreover, there is low heterogeneity in the distribution of GDP and OP in the period of post-global financial crises and pre-pandemic crises. Hence, we conclude that the pattern of the economic activities and prices of oil is significantly less volatile during the normal periods when there is no global crisis. It is evident from Fig. 6 that the warm color dominates the cone, and hence, we conclude that there is strong interconnectedness between GDP and OP during the period of 2011–2019. Moreover, in the cone, the arrows encircled by the black line represent the dimension of the causality. Fig. 6 shows that during the period of 2010–11, arrows point to the left-down at the relatively higher scales of 64 and 512 periods (high frequency), implying that there is unilateral causality from oil prices to economic growth. Hence, we argue that a shock to oil prices in the period of post-financial crises and pre-pandemic crises has important repercussions for economic activities. Moreover, during the period of 2017–18, the path of the arrows is pointed towards right-up at the higher scales of 64 and 512 periods, which imply that there is unilateral causality running from oil prices to economic growth in the short-run. Hence, we infer that any policy to target oil prices significantly influences economic activities. These results support (Foglia and Angelini, 2020b) and (Sheng et al., 2020b) studies, who argue that when it comes to delivering a shock to other sectors of the economy, the natural resources commodity markets are considered to be the most efficient. As a result, commodity markets for natural resources are more closely linked to the financial, stock, and equity markets. Furthermore, it is widely acknowledged that commodities derived from natural resources exhibit particularly volatile behavior during times of crisis. The occurrence of financial crises and pandemics has prompted scholars and policymakers to explore the dynamics of spillovers between oil prices and other macroeconomic variables and activities.

4.3. Oil prices and economic activities during the period of COVID-19 pandemic crises

This study also investigated the co-movement of economic activities and oil prices during the period of COVID crises period. For this purpose, the wavelet power spectrum (WPS) method is used to identify the changes in GDP and oil prices during 2019–2020. The wavelet power spectrum for GDP and oil prices in the period of the COVID-19 pandemic are reported in Figs. 7 and 8, respectively. It is evident from these figures that GDP and OP have shown high power during the period, which indicates higher volatility in economic activities and oil prices during the pandemic period. It is evident from Fig. 8 that the oil prices were mostly vulnerable between 2020–02 to 2020–05 at high frequencies. Moreover, there is high heterogeneity in the distribution of GDP and OP in the period of pandemic crises. Hence, we conclude that the pattern of the economic activities and prices of oil are significantly more volatile during the pandemic era. In the next step, the Wavelet Coherence approach is employed to explore the pattern of co-movements between GDP and oil prices in the period of a global pandemic. We observe a high correlation value between GDP and OP with reference to as in Eq. (6). It is evident from Fig. 9 that the warm color dominates the cone, and hence, we conclude that there is strong interconnectedness between GDP and OP during the period of the pandemic, i.e., 2019 to 2020.

The decision is made based on the arrow inside the cone. The path of the arrow indicates the nature of causality between GDP and OP. In Fig. 3, we observe the path of the arrows to the up-right at the relatively lower scales of the 2 and 4 periods; it follows from this that there is one-way causation from oil prices to economic activity. As a result, we contend that a spike in oil prices during a global financial crisis has major ramifications for the economy. Moreover, we also observe the path of the arrows to the up-right at the high scales of 32 and 64 periods, which imply that there is unilateral causality running from oil prices to economic growth in the short run. Hence, we infer that any policy to target oil prices significantly influences economic activities.

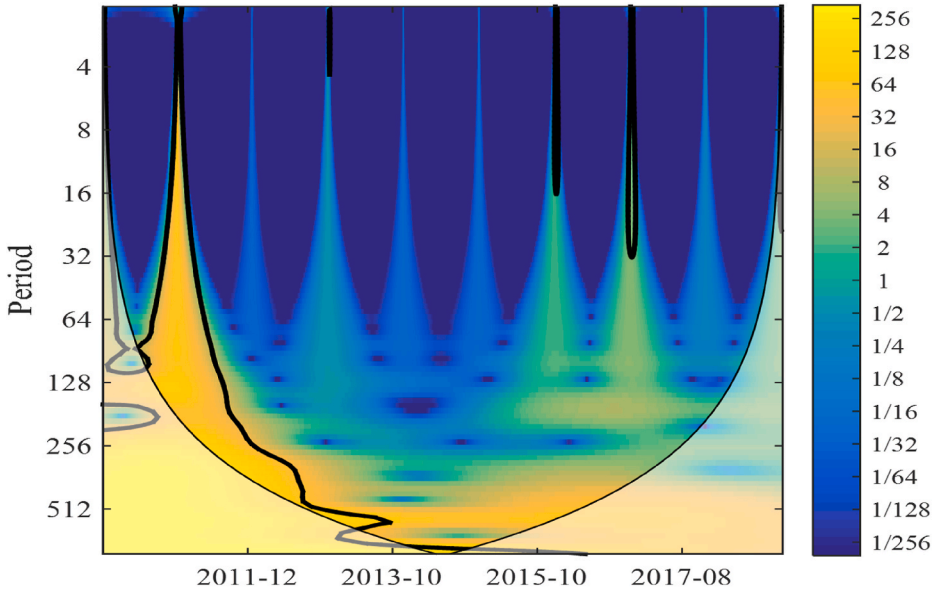

Fig. 4. Wavelet power spectrum for GDP

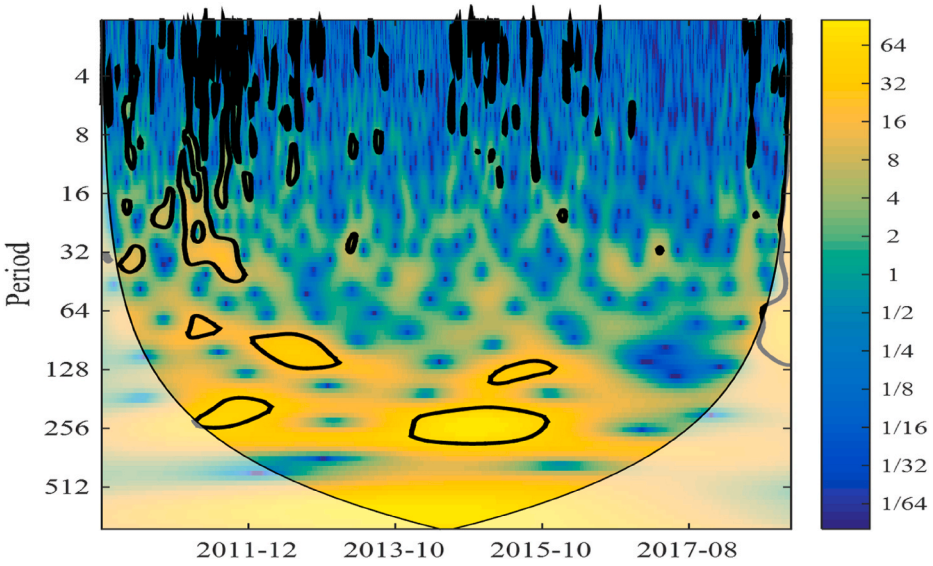

Fig. 5. Wavelet power spectrum for OP.

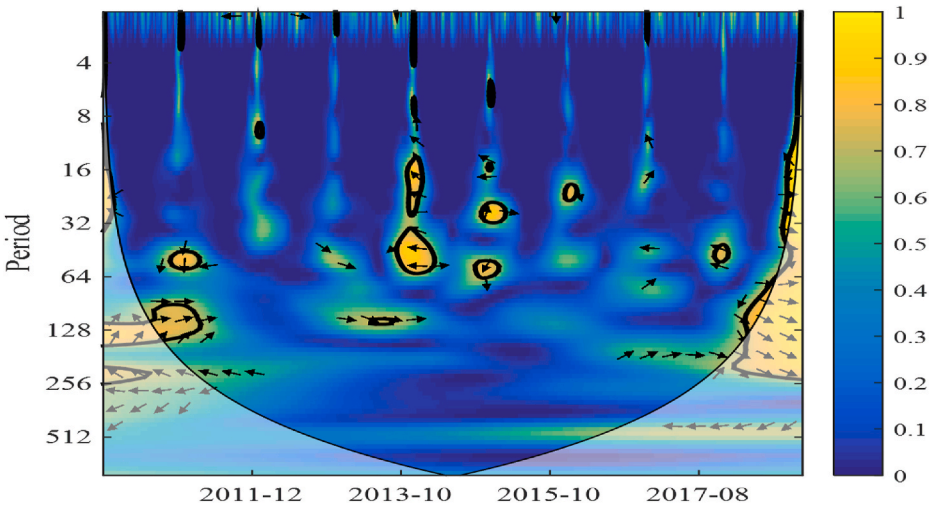

Fig. 6. Wavelet coherence between GDP and OP.

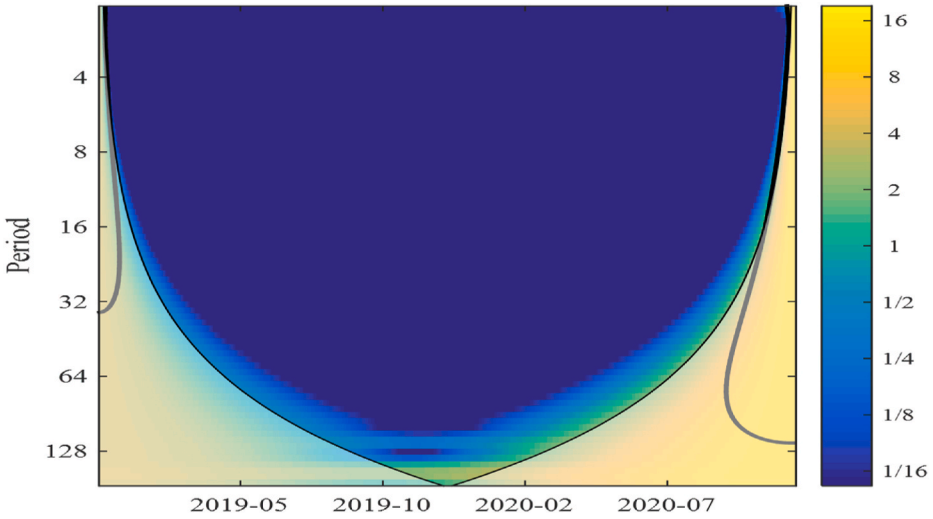

Fig. 7. Wavelet power spectrum for GDP

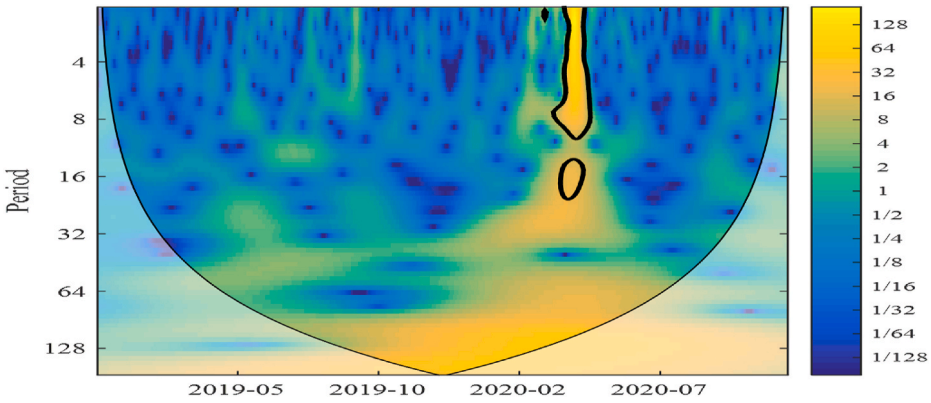

Fig. 8. Wavelet power spectrum for OP.

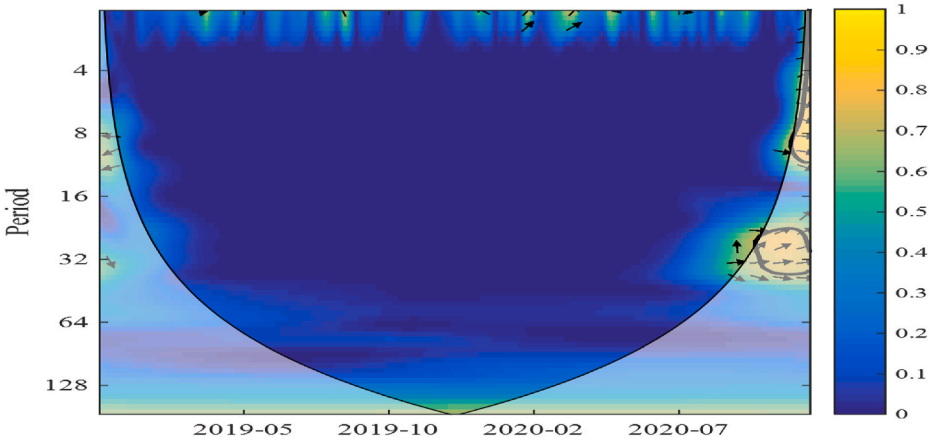

Fig. 9. Wavelet coherence between GDP and OP.

5. Conclusions and policy implications

The natural resources commodity markets are considered as more efficient in sending a shock to other sectors of the economy. However, the interconnectedness among the natural resource market and macroeconomic activities has not been investigated so far. The apparent co-movement of oil prices and macroeconomic activity has caught the interest of researchers, who are now examining the interconnectivity of oil prices and macroeconomic activity in greater depth. With the global financial crisis and the COVID-19 outbreak in mind, this seminal study investigates the spillover effects of volatility between oil and other macroeconomic activity in the post-crisis era. The COVID-19 pandemic has had a significant negative impact on the economy. The oil market, among other things, has been the most adversely affected. A high level of uncertainty in the oil market has posed additional hurdles to governments and investors worldwide, particularly in the Middle East. Because there is a tight nexus between oil and other financial markets, the spillover of oil shocks to other financial markets is expected to be more persistent during the COVID-19 outbreak. As a result, there has been significant volatility observed in other markets. It has been claimed that the COVID-19 epidemic has had a significant impact on both the volatility and returns in the oil market. Hence, it is necessary to conduct a comparative investigation of the dynamics of spillovers between oil price shocks and macroeconomic activities over a variety of different time periods. This study uses a wavelet coherence approach to examine whether there is time-frequency dependency between oil prices and GDP. The approach also explores the causal link between oil prices and economic activities from a global perspective. The wavelet method is used to obtain highly valued information about the time-frequency movement between the variables. Based on the results, we find (i) there is strong interconnectedness between GDP and OP during the period of global financial crises; ii) a shock in oil prices has repercussions for economic activities in the long run iii) in the short-run, there is unilateral causality running from oil prices to economic growth; iv) any policy to target oil prices significantly influences economic activities; v) there is strong interconnectedness between GDP and OP during the period of 2011–2019; vi) Between 2011 and 2019, stable co-moments between oil prices and economic activities are observed; vii) the pattern of the economic activities and prices of oil are significantly more volatile during the pandemic era; ix) there is strong interconnectedness between GDP and OP during the period of the pandemic, i.e., 2019 to 2020; x) in the short-run, there is unilateral causality running from oil prices to economic growth.

This study examines pertinent policy implications to understand the volatility nature of oil prices and prescribe appropriate policy responses. In terms of policy implications, it is suggested that policy initiatives may would be helpful to mitigate the rapid drop in oil prices. Governments may ease the restriction of lockdowns and restart their economies to support the oil market. Furthermore, economies must prepare for potential disasters. It's worth noting that the Covid-19 epidemic had a significant long-term impact on oil prices in this study. The oil markets will be able to return to normal once the coronavirus has been eradicated.

Declaration of competing interest

We declare that there is not conflict of interest.

Data availability

Data will be made available on request.

References

Abdelsalam, M.A.M., 2020. Oil price fluctuations and economic growth: the case of MENA countries. Review of Economics and Political Science, forthcoming.

Ahmad, N., Du, L., 2017. Effects of energy production and CO2 emissions on economic growth in Iran: ARDL approach. Energy 123, 521–537.

Akinsola, M.O., Odhiambo, N.M., 2020. Asymmetric effect of oil price on economic growth: panel analysis of low-income oil-importing countries. Energy Rep. 6, 1057–1066.

Aloui, D., Goutte, S., Guesmi, K., Hchaichi, R., 2020. COVID 19's Impact on Crude Oil and Natural Gas S&P GS Indexes.

Ashraf, B.N., 2020. Stock markets' reaction to COVID-19: cases or fatalities? Res. Int. Bus. Finance 54, 101249.

Awartani, B., Aktham, M., Cherif, G., 2016. The connectedness between crude oil and financial markets: evidence from implied volatility indices. Journal of Commodity Markets 4, 56–69.

Aydin, C., Esen, O., 2016. Threshold effects of energy consumption on economic growth in Turkey. Journal of Environmental Management and Tourism 3, 370–382.

Bhowmik, S.S.D., Brinin, A.K., Williams, B., Mundree, S.G., 2016. Sugarcane biotechnology: tapping unlimited potential. Sugarcane-based biofuels and bioproducts.

Bibi, A., Zhang, X., Umar, M., 2021. The imperativeness of biomass energy consumption to the environmental sustainability of the United States revisited. Environ. Ecol. Stat. https://doi.org/10.1007/s10651-021-00500-9.

Bildirici, M., Guler Bayazit, N., Ucan, Y., 2020. Analyzing crude oil prices under the impact of covid-19 by using lstargarchlstm. Energies 13, 2980.

Bouri, E., Demirer, R., Gupta, R., Pierdzioch, C., 2020. Infectious diseases, market uncertainty and oil market volatility. Energies 13, 4090.

Cong, R.-G., Wei, Y.-M., Jiao, J.-L., Fan, Y., 2008. Relationships between oil price shocks and stock market: an empirical analysis from China. Energy Pol. 36, 3544–3553.

Darby, M.R., 1982. The price of oil and world inflation and recession. Am. Econ. Rev. 72, 738–751.

Das, S., 2021. The time–frequency relationship between oil price, stock returns and exchange rate. Journal of Business Cycle Research 1–21.

Du, L., Yanan, H., Wei, C., 2010. The relationship between oil price shocks and China's macro-economy: an empirical analysis. Energy Pol. 38, 4142–4151.

Dutta, A., Bouri, E., Uddin, G.S., Yahya, M., 2020. Impact of COVID-19 on global energy markets. In: IAEE Energy Forum Covid-19 Issue, pp. 26–29.

Essaadi, E., Boutahar, M., 2008. A measure of variability in comovement for economic variables: a time-varying coherence function approach. Econ. Bull. 30, 1054–1070.

Foglia, M., Angelini, E., 2020a. Volatility connectedness between clean energy firms and crude oil in the COVID-19 era. Sustainability 12, 9863.

Foglia, M., Angelini, E., 2020b. Volatility connectedness between clean energy firms and crude oil in the COVID-19 era. Sustainability 12, 9863.

Gu, J., Umar, M., Soran, S., Yue, X.-G., 2020. Exacerbating effect of energy prices on resource curse: can research and development be a mitigating factor? Resour. Pol. 67, 101689. https://doi.org/10.1016/j.resourpol.2020.101689.

Hamilton, J.D., 2009a. Causes and Consequences of the Oil Shock of 2007-08. National Bureau of Economic Research.

Hamilton, J.D., 2009b. Causes and Consequences of the Oil Shock of 2007-08. National Bureau of Economic Research.

Hooker, M.A., 1996. What happened to the oil price-macroeconomy relationship? J. Monetary Econ. 38, 195–213.

Jeris, S.S., Nath, R.D., 2020. Covid-19, oil price and UK economic policy uncertainty: evidence from the ARDL approach. Quantitative Finance and Economics 4, 503–514.

Ji, X., Chen, X., Mirza, N., Umar, M., 2021. Sustainable energy goals and investment premium: evidence from renewable and conventional equity mutual funds in the Euro zone. Resour. Pol. 74, 102387. https://doi.org/10.1016/j.resourpol.2021.102387.

Khan, K., Su, C.-W., Umar, M., Yue, X.-G., 2020. Do crude oil price bubbles occur? Resour. Pol. 101936 https://doi.org/10.1016/j.resourpol.2020.101936.

Kilian, L., 2008. The economic effects of energy price shocks. J. Econ. Lit. 46, 871–909.

Kirikkaleli, D., Güngör, H., 2021. Co-movement of commodity price indexes and energy price index: a wavelet coherence approach. Financial Innovation 7, 1–18.

Le, T.-H., Le, A.T., Le, H.-C., 2021. The historic oil price fluctuation during the Covid-19 pandemic: what are the causes? Res. Int. Bus. Finance 58, 101489.

Li, Z.Z., Su, C.-W., Qin, M., Umar, M., 2020. Who is the chaser in cryptocurrencies? Singapore Econ. Rev 1–22. https://doi.org/10.1142/S0217590820470049.

Maghyereh, A.I., Awartani, B., Bouri, E., 2016. The directional volatility connectedness between crude oil and equity markets: new evidence from implied volatility indexes. Energy Econ. 57, 78–93.

Marinaș, M.-C., Dinu, M., Socol, A.-G., Socol, C., 2018. Renewable energy consumption and economic growth. Causality relationship in Central and Eastern European countries. PLoS One 13, e0202951.

Mensi, W., 2019. Global financial crisis and co-movements between oil prices and sector stock markets in Saudi Arabia: a VaR based wavelet. Borsa Istanbul Review 19, 24–38.

Mustapha, A.M., Fagge, A.M., 2015. Energy consumption and economic growth in Nigeria: a causality analysis. J. Econ. Sustain. Dev. 6 (13).

Narayan, P.K., 2020. Has COVID-19 changed exchange rate resistance to shocks? Asian Economics Letters 1, 17389.

Nasreen, S., Tiwari, A.K., Eizaguirre, J.C., Wohar, M.E., 2020. Dynamic connectedness between oil prices and stock returns of clean energy and technology companies. J. Clean. Prod. 260, 121015.

Okonjo-Iweala, N., 2009. Africa's growth and resilience in a volatile world. J. Int. Aff. 62, 175–184.

Qin, M., Qiu, L.-H., Tao, R., Umar, M., Su, C.-W., Jiao, W., 2020. The inevitable role of El Niño: a fresh insight into the oil market. Economic Research-Ekonomska Istraživanja 33, 1943–1962. https://doi.org/10.1080/1331677X.2020.1768428.

Ramsey, J.B., 2002. Wavelets in economics and finance: past and future. Stud. Nonlinear Dynam. Econom. 6.

Rasche, R.H., Tatom, J.A., 1977. The effects of the new energy regime on economic capacity, production, and prices. Fed. Reserv. Bank St. Louis Rev. 59, 2–12.

Reboredo, J.C., 2015. Is there dependence and systemic risk between oil and renewable energy stock prices? Energy Econ. 48, 32–45.

Rizwan, M.S., Ahmad, G., Ashraf, D., 2020. Systemic risk: the impact of COVID-19. Finance Res. Lett. 36, 101682.

Sadorsky, P., 2012. Correlations and volatility spillovers between oil prices and the stock prices of clean energy and technology companies. Energy Econ. 34, 248–255.

Sharif, A., Aloui, C., Yarovaya, L., 2020. COVID-19 pandemic, oil prices, stock market, geopolitical risk and policy uncertainty nexus in the US economy: fresh evidence from the wavelet-based approach. Int. Rev. Financ. Anal. 70, 101496.

Sheng, X., Gupta, R., Ji, Q., 2020a. The impacts of structural oil shocks on macroeconomic uncertainty: evidence from a large panel of 45 countries. Energy Econ. 91, 104940.

Sheng, X., Gupta, R., Ji, Q., 2020b. The impacts of structural oil shocks on macroeconomic uncertainty: evidence from a large panel of 45 countries. Energy Econ. 91, 104940.

Su, C.-W., Huang, S.-W., Qin, M., Umar, M., 2021a. Does crude oil price stimulate economic policy uncertainty in BRICS? Pac. Basin Finance J. 66, 101519. https://doi.org/10.1016/j.pacfin.2021.101519.

Su, C.-W., Qin, M., Tao, R., Umar, M., 2020a. Financial implications of fourth industrial revolution: can bitcoin improve prospects of energy investment? Technol. Forecast. Soc. Change 158, 120178.

Su, C.-W., Qin, M., Tao, R., Umar, M., 2020b. Financial implications of fourth industrial revolution: can bitcoin improve prospects of energy investment? Technol. Forecast. Soc. Change 158, 120178. https://doi.org/10.1016/j.techfore.2020.120178.

Su, C.-W., Yuan, X., Tao, R., Umar, M., 2021b. Can new energy vehicles help to achieve carbon neutrality targets? J. Environ. Manag. 297, 113348. https://doi.org/10.1016/j.jenvman.2021.113348.

Tang, C.F., Tan, B.W., Ozturk, I., 2016. Energy consumption and economic growth in Vietnam. Renew. Sustain. Energy Rev. 54, 1506–1514.

Umar, M., Ji, X., Kirikkaleli, D., Alola, A.A., 2021a. The imperativeness of environmental quality in the United States transportation sector amidst biomass-fossil energy consumption and growth. J. Clean. Prod. 285, 124863. https://doi.org/10.1016/j.jclepro.2020.124863.

Umar, M., Ji, X., Kirikkaleli, D., Xu, Q., 2020. COP21 Roadmap: do innovation, financial development, and transportation infrastructure matter for environmental sustainability in China? J. Environ. Manag. 271, 111026. https://doi.org/10.1016/j.jenvman.2020.111026.

Umar, M., Ji, X., Mirza, N., Rahat, B., 2021b. The impact of resource curse on banking efficiency: evidence from twelve oil producing countries. Resour. Pol. 72, 102080. https://doi.org/10.1016/j.resourpol.2021.102080.

Umar, M., Su, C.-W., Rizvi, S.K.A., Lobonț, O.-R., 2021c. Driven by fundamentals or exploded by emotions: detecting bubbles in oil prices. Energy 231, 120873. https://doi.org/10.1016/j.energy.2021.120873.

Wang, K.-H., Su, C.-W., Umar, M., 2021. Geopolitical risk and crude oil security: a Chinese perspective. Energy 219, 119555. https://doi.org/10.1016/j.energy.2020.119555.

Yan, L., Mirza, N., Umar, M., 2021. The cryptocurrency uncertainties and investment transitions: evidence from high and low carbon energy funds in China. Technol. Forecast. Soc. Change 121326. https://doi.org/10.1016/j.techfore.2021.121326.

Yarovaya, L., Mirza, N., Abaidi, J., Hasnaoui, A., 2021. Human capital efficiency and equity funds' performance during the COVID-19 pandemic. Int. Rev. Econ. Finance 71, 584–591.

Zhang, J., Dai, Y., Su, C.-W., Kirikkaleli, D., Umar, M., 2021. Intertemporal Change in the Effect of Economic Growth on Carbon Emission in China. Energy & Environment 0958305X211008618. https://doi.org/10.1177/0958305X211008618.